TIME OF SEEDING WHEAT AND CANOLA AFTER SPRING BANDING OF ANHYDROUS AMMONIA

H. Ukrainetz
Agriculture Canada Research Station, Saskatoon

ABSTRACT

A study was carried out on a Dark Brown Scott loam at Scott, Saskatchewan to determine the effects of time of seeding after banding of anhydrous ammonia at two depths in spring on plant stands, grain yields and quality of wheat and canola.

Observations of emergence, early growth and determinations of plant populations and yields indicated no detrimental effects from anhydrous ammonia banded at 30 cm spacing at depths of 10 or 15 cm when seeding was done at 22 cm row spacing at recommended depths for wheat and canola immediately after application of anhydrous ammonia or during the following three to eight day period. Differences in stands and yield from different dates of seeding appeared to be related to precipitation and changes in soil moisture and seedbed conditions subsequent to the first seeding date.

Plant populations, grain yield increases, and % protein and % oil in grain (canola) on plots where anhydrous ammonia was banded at 10 cm depth were generally equal to or greater than where ammonia was banded at 15 cm depth.

Seeding during most of the study carried out in a direction parallel to the anhydrous ammonia bands so that seed rows were at various distances laterally from the ammonia bands. However, in 1987, seeding in a direction perpendicular to the ammonia bands did not result in any visual or measured harmful effects on stands or yields of wheat or canola attributable to the anhydrous ammonia.

INTRODUCTION

The differences frequently observed in crop tolerance during the germination - seedling emergence stage to seed placed ammonium nitrate and urea have been shown to be related to toxic ammonia accumulation upon urea hydrolysis in soil. It is possible to have toxic effects from anhydrous ammonia (A.A.) injected into soil if the ammonia zone envelopes the seed or if seeding is done immediately into an anhydrous ammonia zone in the soil.

Fall application of nitrogen fertilizers is a common practice for cereal and oilseed production in western Canada. Research has shown that fall banding of urea and anhydrous ammonia can be less effective than spring banding under certain conditions. The later in the fall that ammonium nitrogen fertilizers are banded (into cool soils) the less potential for denitrification losses. Late fall banded urea and A.A. are frequently equal to or more effective than spring banded applications. However, either by choice or the inability to complete N applications in the fall, it is frequently necessary to apply A.A. in the spring. Nitrogen fertilizer efficiency is generally highest when the fertilizer is applied as close as possible to the time when the crop needs it - in early spring. As a precaution, to avoid potential crop injury, farmers usually delay

seeding for several days after banding A.A. For crops such as spring wheat and *B. napus* canola, such delays in seeding may be hazardous and may result in lower yields due to frost and inclement harvest weather, especially if weather conditions in spring delay ammonia application into prime seeding time.

Injury to germinating seedlings could occur if seed is placed into the A.A. expansion zone in the soil. Studies by Hogg and Henry (1982) showed that more than 90% of the NH_4+N from A.A. application was retained in a zone 5 cm in diameter from the injection point. Thus, A.A. banding depth and seeding depth would be critical factors in injury avoidance. In field experiments carried out at Crookston, Minn. (Varvel 1982) seedling stands of wheat and barley were significantly reduced in some cases by A.A. applied at or near seeding, but the effects of application depth on yields was related primarily to the effects of the banding tillage on seedbed condition and soil drying. In a two year field study in Oklahoma (Jacobson, et al 1986), seedling stand of winter wheat were not decreased when A.A. was banded at 12.7 cm depth at seeding time or over a period of several days after seeding, at rates up to 200 kg N/ha.

Canola is quite sensitive to certain fertilizers placed with or close to the seed, especially in relatively dry soil. The studies reported herein were undertaken to determine the effects of rates of spring banded A.A., depth of banding, and time of seeding after A.A. banding on canola in comparison to wheat

MATERIALS AND METHODS

The field experiments were carried out during a five year period on a Dark Brown loam soil at the Agriculture Canada Experimental Farm at Scott, Saskatchewan.

Soil samples were taken from plot sites in spring prior to A.A. banding or seeding. Samples were taken from the 0-60 cm depth for NO_3-N and SO_4-S, and from 0-15 cm for pH ($CaCl_2$), organic matter (dichromate oxidation) and $NaHCO_3$-extractible P and K.[2] Soil analyses data are shown in Table 1.

Table 1. Soil properties at test sites.

Soil Type	Year	pH ($CaCl_2$)	O.M. %	Available Nutrients NO_3-N	$NaHCO_3$ - extr P	$NaHCO_3$ - extr K	SO_4-S
				kg/ha			
Scott loam	1983	6.0	4.5	37	11	475	48
Scott loam	1984	5.9	4.2	42	24	555	46
Scott loam	1985	5.8	4.7	22	30	852	
Scott loam	1986	6.0	4.5	75	37	527	
Scott loam	1987	6.0	4.5	16	53	717	79

pH, O.M., P and K were determined on 0-15 cm samples NO_3-N and SO_4-S were determined 0-60 cm samples.

Anhydrous ammonia was banded on stubble for both wheat and canola. The ammonia was injected into the soil with narrow knives at 30 cm spacing and depths of 10 and 15 cm at rates of 0, 45, 90 and 135 kg N/ha. Canola and wheat were seeded at row spacing of 22 cm at depths of 4-5 cm and 2.5-3.5 cm, respectively, using a double disc opener plot seeder. From 1983 to 1987 seeding was done in a direction parallel to the A.A. bands. The effects of perpendicular seeding were evaluated in additional experiments in 1987. Levels of K and S in the soil were adequate for the crops grown. Phosphorous was applied as ammonium phosphate in the seed row for wheat and sidebanded for canola, according to soil test requirements.

In the main experiment, seeding was done immediately after A.A. banding and at 1, 2, and 3 days after banding. In two instances, because of weather conditions, the last seeding was done on the 6th day after A.A. banding. In additional experiments carried out in 1987, seeding was done immediately after and on the 4th day after banding of A.A. and urea at a rate of 90 kg N/ha at 10 cm depth and 30 cm spacing. In all cases, checks (0 fertilizer) consisted of pulling the bander blades through the soil without fertilizer application.

Plant emergence counts, grain yields and protein contents were used to evaluate responses of the two crops. Plant stands were determined shortly after tiller initiation by counting four one-meter lengths of row per plot. Individual plot size was 1.8 x 6 m, consisting of eight seeded rows. Experimental design for the main experiment was a split-split plot, with dates of seeding as main plots, N rate as subplots and banding depth as sub-subplots, with four replicates. The additional experiments carried out in 1987 were arranged as a split plot design with N treatments as main plots and seeding dates as subplots. Plots were harvested with a plot combine for yield, and representative samples of grain were taken from each plot for protein and oil content (canola) determination.

RESULTS AND DISCUSSION

Plant Stand Density

Significant differences in plant emergence and stand density resulted in some years, from seeding wheat and canola at different times following spring banding of A.A. as shown in Table 2. In some years plant stands were highest when seeding was done immediately after banding A.A. and decreased on succeeding dates, and in other instances stands were highest from later seedings. However, the differences in plant stands were not a result of detrimental effects of ammonia, but appeared to be related to seedbed condition as affected by soil disturbance and moisture conditions. Seeding immediately after banding A.A., with proper packing of the soil over the seed rows resulted in conservation of seedbed moisture and good germination. Later seedings tended to suffer from decreased moisture in the soil unless rainfall occurred soon after banding of the A.A.

Plant stands were not significantly affected by banding of A.A. except in one year - 1985, where wheat emergence was improved by all rates of applied A.A. Depth of banding of A.A. did not affect plant stand density. No observable toxic effects occurred from seeding wheat or canola immediately after banding of A.A. at 10 or 15 cm depth at any rate of applied N.

Table 2. Effects of anhydrous ammonia on plant emergence of spring wheat and canola seeded at different dates.

Variable	Plants/m of row						
	Wheat			Canola			
	1984	1985	1986	1984	1985	1986	1987
Seeding Date (D)							
0	34.6	37.6	30.4	28.4	23.5	18.9	17.9
1	35.1	31.1	30.0	29.3	22.6	20.9	19.8
2	35.1	31.4	29.1	29.2	14.0	19.9	23.4
3	34.3	30.4	31.0	27.6	12.1	22.3	27.1
	N.S.	**	*	N.S.	**	*	**
N Rate (N)							
0	34.9	29.8	30.4	26.5	18.0	20.8	22.5
45	36.8	33.5	30.0	29.5	18.4	19.9	22.0
90	33.2	33.5	30.2	28.8	17.3	19.8	22.0
135	34.3	33.9	29.8	29.8	18.5	21.5	21.9
	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.
Banding Depth (BD)							
10	34.4	32.9	29.8	27.8	17.7	20.3	21.9
15	35.1	32.4	30.4	29.5	18.4	20.7	22.3
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D X N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D X BD	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.
N X BD	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** indicates significance at the 0.05 and 0.01 levels.
N.S. - not significant

Grain Yields

In most years highest grain yields of wheat and canola were obtained from seedi immediately after banding A.A. as shown in Table 3. Where higher yields occurr from delayed seedings, they were not related to higher plant stand density, thu not directly related to effects of A.A. at germination and seedling emergence. Yields varied between seeding dates with no consistent pattern of response in wheat or canola.

Yields of wheat and canola were substantially increased with increasing rates o applied ammonia N when soil NO_3-N levels were low. Low response to applied A.A was not related to plant stands but was affected by high available soil N and/o moisture stress.

Yields of wheat and canola were higher when A.A. was banded at 10 cm depth compared to 15 cm depth in 1985, but yields were not significantly affected by depth of banding in other years. Deeper banding may cause greater soil disturbance and result in a poorer seedbed with lower moisture levels in the soil.

Table 3. Effects of anhydrous ammonia on grain yields of spring wheat and canola seeded at different dates.

	Grain yields - kg/ha							
	Wheat				Canola			
Variable	1983	1984	1985	1986	1983	1984	1985	1987
Seeding Date (D)								
0	3149	1931	3152	3029	659	1046	1249	2741
1	2447	1865	3165	2906	455	1123	1418	2578
2	2564	2143	3704	2982	357	1347	1557	2318
3	2822	1892	3110	2705	526	1182	1464	2351
	**	**	**	**	**	**	**	**
N Rate (N)								
0	2038	1923	2140	3166	261	1262	855	2050
45	2822	1968	3361	2872	508	1091	1354	2657
90	3014	1954	3722	2872	629	1156	1715	2702
135	3107	1986	3909	2712	599	1189	1734	2579
	**	N.S.	**	**	**	**	**	**
Banding Depth (BD)								
10	2744	1975	3388	2911	505	1164	1466	2486
15	2747	1941	3178	2900	494	1185	1378	2509
	N.S.	N.S.	**	N.S.	N.S.	N.S.	**	N.S.
D X N	N.S.	N.S.	*	N.S.	**	**	**	N.S.
D X BD	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N X BD	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.

Protein content in Grain

Protein contents in grain of wheat and canola varied somewhat between dates of seeding from year to year but there was no consistent pattern overall (Table 4). Seeding immediately after banding of A.A. usually produced maximum or near maximum protein contents.

Protein contents in grain of wheat and canola increased with increasing rate of applied A.A. Protein contents were either unaffected by depth of A.A. application or were higher with the shallower banding.

Oil content in canola (data not shown) tended to follow the usual response pattern, decreasing with increasing rate of N.

Table 4. Effects of anhydrous ammonia on protein contents of spring wheat and canola seeded at different dates.

Variable	% Protein				
	Wheat			Canola	
	1983	1985	1986	1985	1987
Seeding Date (D)					
0	12.0	13.3	16.4	22.3	22.6
1	11.9	13.0	16.8	20.0	22.3
2	12.0	11.3	16.3	19.6	23.4
3	11.6	12.5	16.8	21.4	22.0
	N.S.	**	**	**	**
N Rate (N)					
0	9.3	10.6	15.5	18.5	20.2
45	11.6	11.6	16.6	20.1	22.9
90	13.2	13.7	16.9	22.1	23.1
135	13.4	14.2	17.4	22.5	24.1
	**	**	**	**	**
Banding Depth (BD)					
10	12.0	12.8	16.6	21.2	22.4
15	11.7	12.2	16.6	20.4	22.8
	*	**	N.S.	**	N.S.
D X N	N.S.	N.S.	*	**	N.S.
D X BD	N.S.	N.S.	N.S.	N.S.	N.S.
N X BD	*	*	N.S.	N.S.	N.S.

The results from this study indicate that variations in plant stands, grain yields, and protein contents for different dates of seeding after banding anhydrous ammonia were not related to any harmful effects of the ammonia treatments. Figures 1 and 2 present data averaged over years for the variables studied, and show effects of rates of N and depths of banding of A.A. at each seeding date.

Additional experiments carried out in 1987 to compare parallel and perpendicula seeding after banding of A.A. and urea largely confirm the results of the longe term study. Data presented in Tables 5, 6, and 7 show that substantial variations occurred in plant stands and yields of wheat and canola between 0 an 4th day seedings, but these were not related to any harmful effects of the fertilizer, as the check (non fertilized) treatments generally showed similar variations. The effects of soil disturbance and moisture loss, and subsequent moisture conditions as well as initial soil N levels appear to have been the primary factors influencing plant stands and yields.

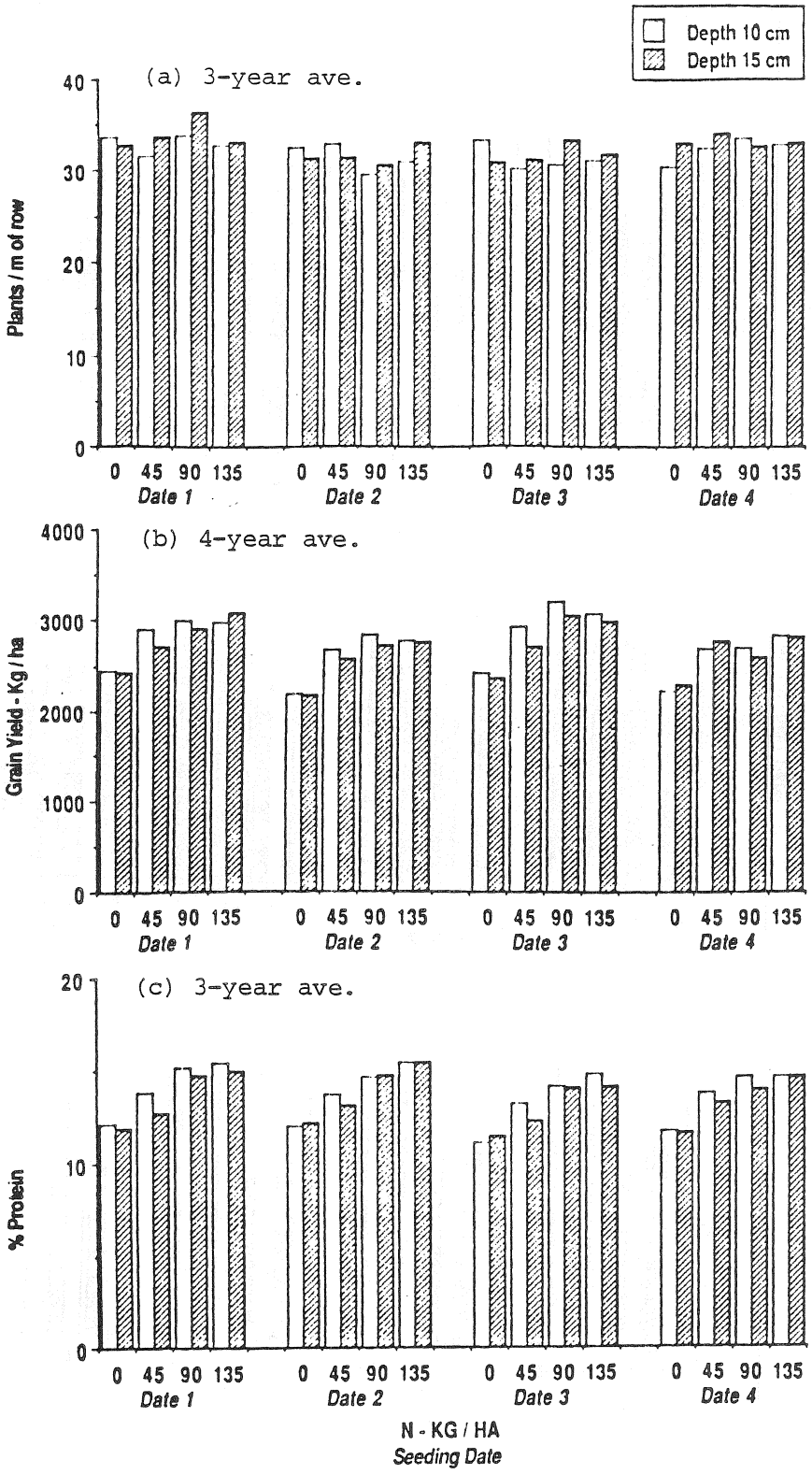

Figure 1. The effects of seeding date, N rate and depth of banding of A.A. for spring wheat (data averaged over years).

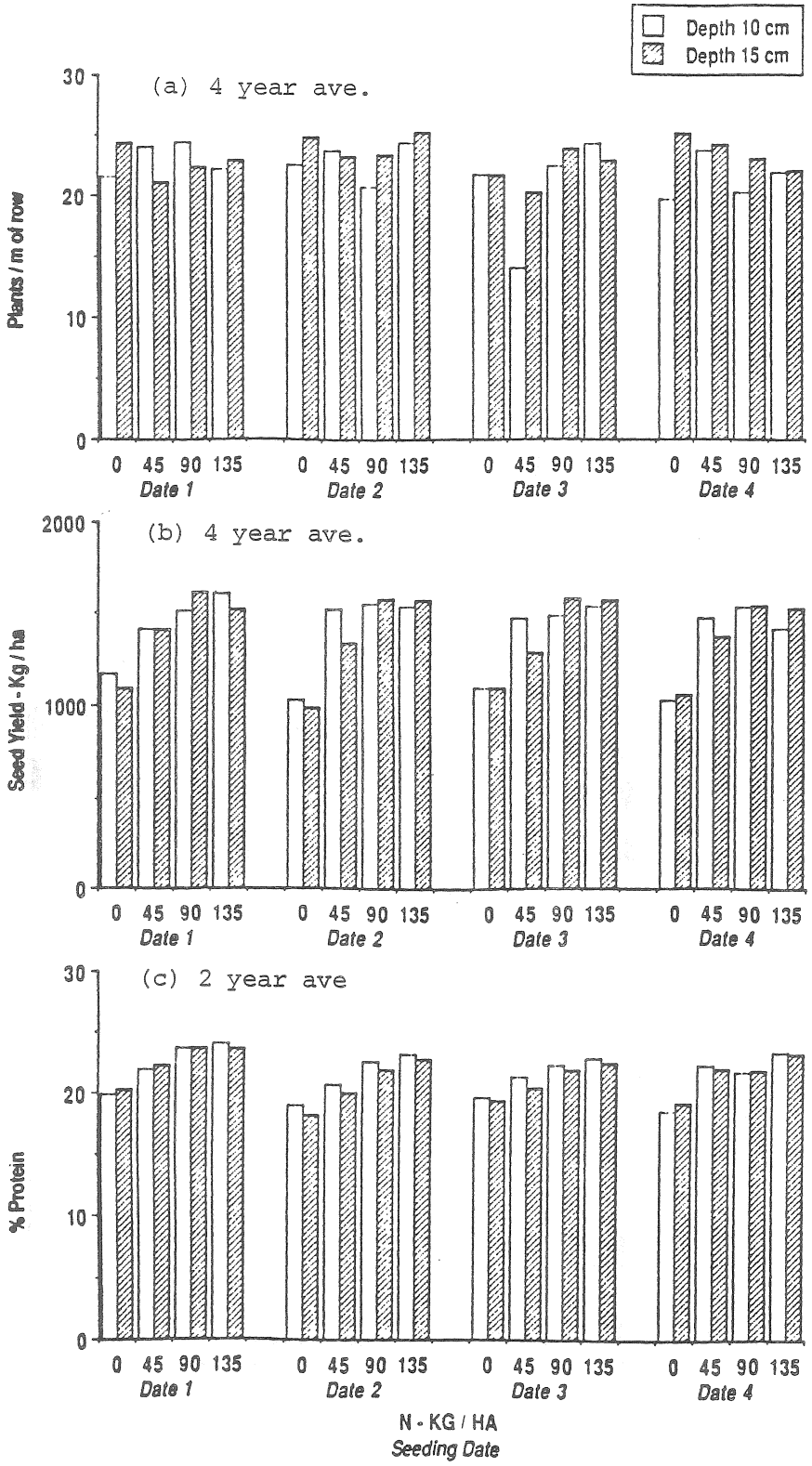

Figure 2. The effect of seeding date, N rate and depth of banding of A.A. for canola (data averaged over years).

Table 5. Effect of time of seeding wheat after banding anhydrous ammonia and urea - 1987

N Source	Seeding Date	Parallel Seeding Plants/m of row	Parallel Seeding Yield kg/ha	Parallel Seeding Protein %	Perpendicular Seeding Plants/m of row	Perpendicular Seeding Yield kg/ha	Perpendicular Seeding Protein %
A.A.	D0	30.1	3324	15.3	25.8	1546	16.4
	D4	28.2	3314	15.3	23.7	2209	15.8
Urea	D0	27.8	2978	14.7	26.4	1410	14.6
	D4	27.9	3657	15.0	25.0	2372	14.6
Check	D0	27.8	2482	14.3	24.7	954	14.8
	D4	26.0	2798	14.5	24.9	1541	15.1
F Value	Fertilizer		*	**		**	**
	Seeding Date					**	
	Fert x Date						

N applied at 90 kg/ha
D0 - seeded immediately after banding fertilizer
D4 - seeded on 4th day after banding fertilizer

Table 6. Effect of time of seeding canola after banding anhydrous ammonia and urea - 1987

N Source	Seeding Date	Parallel Seeding Plants/m of row	Parallel Seeding Yield kg/ha	Parallel Seeding Protein %	Perpendicular Seeding Plants/m of row	Perpendicular Seeding Yield kg/ha	Perpendicular Seeding Protein %
A.A.	D0	20.1	1972	23.4	17.4	1986	23.5
	D4	25.5	2250	22.3	30.6	2138	23.4
Urea	D0	19.7	2076	21.7	16.2	1950	22.7
	D4	24.5	2471	22.7	25.2	2303	22.2
Check	D0	18.6	1953	22.5	26.4	1872	23.3
	D4	30.4	1657	21.7	27.7	2221	23.2
F value	Fertilizer			*			*
	Seeding Date **		*			**	
	Fert x Date		**				

Table 7. Effect of time of seeding wheat after banding anhydrous ammonia and urea - 1987 (later seeding)

N Source	Seeding Date	Parallel Seeding Plants/m of row	Parallel Seeding Yield kg/ha	Parallel Seeding Protein %	Perpendicular Seeding Plants/m of row	Perpendicular Seeding Yield kg/ha	Perpendicular Seeding Protein %
A.A.	D0	31.0	3629	15.0	30.2	3059	14.9
	D4	29.0	2928	14.4	28.6	3025	14.6
Urea	D0	31.8	3269	14.4	32.2	3005	14.3
	D4	29.6	2700	13.8	31.5	3112	13.8
Check	D0	31.9	1879	14.8	35.2	2263	14.3
	D4	28.3	2512	13.6	30.4	2354	13.3
F value Fertilizer			**	*		**	*
	Seeding Date **		*	**	*		**
	Fert x Date		**				*

SUMMARY AND CONCLUSIONS

1. Seeding of spring wheat and canola at recommended depths immediately after banding of A.A. at 10 cm depth in a loam soil at rates up to 135 kg N/ha di not reduce seedling stands or grain yields. Significant responses to N wer obtained in grain yields and grain protein content, similar to those obtained from pre-seeding banding of urea at similar depths. These results confirm results of studies done in Minnesota (Varvel 1982) and Oklahoma (Jacobson, et al. 1986).

2. Provided adequate separation is maintained in the soil between seed rows or bands and A.A. bands, simultaneous A.A. banding and seeding should be feasible. A separation distance of 5 cm would appear to be adequate in loa soil.

3. In very light textured soils, it may be advisable to band the A.A. slightly deeper.

4. Proper packing of the soil over the seed rows to firm the banding-disrupted soil, to minimize moisture loss and hasten germination and emergence of seedlings is of much greater importance than delaying seeding to avoid potential stand reductions from ammonia.

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